KRICK MESSTECHNIK & PARTNER KG

General operating instructions

for

Thermocouples
and
Resistance probes

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General operating instructions for thermocouples and resistance probes

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Before starting any operation, please consult the instructions
Keep them for future use!

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1. Introduction

This manual consists of instructions for installation, maintenance and repairs of devices. Before putting any device into operation, the manual shall be read thoroughly by the operator as well as relevant people and shall be available at the installation place at all times.
The manual does not exempt the operators from verifying our indications as well as recommendations under its personal responsibility and for personal use.
This particularly applies to exportation, concerning the conservation of third party's protection rights and the applications as well as process methods, which is not expressly indicated in writing.
In case of damages or quality defects, our responsibility is limited to compensatory benefits, as indicated in our general conditions of sales. Any reimbursements for subsequent costs and defective sensors' immobilizations are excluded.

2 Structure and function

2.1 General information

The sensors provided are completely assembled and can be directly integrated and be put into operation. Containing sometimes glass or ceramic elements, these thermocouples and resistance probes are sensitive to vibrations; therefore, they must be handled with special care.
Sensitive to humidity, these devices must be protected from condensation and from standing water through appropriate measures during storage and transportation.
Once received, the sensors must be verified for possible defects, if this is the case, the defects must be reported to the carrier.
The delivered articles may contain separated assembly components, which should not be lost during unpacking.
When handling sensors with great dimensions, the sensors must be supported, properly lifted, and transported with all necessary precautions.
The same attention is required to assembly process.
During unpacking, remember to verify the sensors for eventual deteriorations that could occur during transportation.

2.2 Thermocouples

Thermocouples are made of two metal conductors (thermocouple wires) welded together (measurement point or hot spot). If the junction area is heated to a temperature that differs from the temperature at the other ends of the thermoelectric wires, the thermocouple will generate a small electric voltage du to temperature deviations.
This effect, known as Seebeck effect, serves as a reference to the temperature measurement by thermoelectric voltage evaluation and conversion in thermal difference between hot and cold ends using standard tables.

Thermocouples may include one or more thermoelectric wires. The industrial thermocouples are protected by a sheath to preserve their thermoelectric wires. This kind of sheath is made of metal, ceramics, or other materials upon request of the client.
The measuring point is isolated from sleeve or not.

If the thermocouple cannot be directly connected with the equipment in its position, connecting cables with the appropriate extension length shall be used, which is called the compensating cable or the extending cable.
In this case, it is absolutely necessary to pay attention to the choice of compensating cables especially to the correct polarity.
During the wiring, it is necessary to respect the CEM specifications (twisted cables must keep at least 50 cm's distance from electric wires) since the signals of thermocouples can be located only in small mV, and electric disruption may lead to measuring errors.

2.3 Resistance probes

The temperature measurement by resistance probes are based on metal conductors' property of varying the electrical resistance in function of different temperatures.

Platinum (or nickel and molybdenum)is often used as the probe's material owing to its resistance to chemical corrosion and oxidation at high temperature.
A thin platinum Pt wire is either wound helically, encapsulated with suitable material (glass or ceramics) or available in Pt layer on a substrate, which produces the sensors with a nominal value of 100 Ω at 0 °C (Pt100) or 1000 Ω at 0°C.

Depending on the application in accordance with each measurement sequence, the sensor elements are combined into resistance thermometers with protection sheaths and connecting heads or cable connecting. It may include one sensor (one measuring point) or several sensors (multiple points).
The measuring point of the resistance probe is always isolated from the protection sheath.
The connection of the resistance probe with the measuring device is realized through 2,3 or 4-wire circuits.
Classic copper wires are recommended for the connecting circuits (low ohm value, section approx. 1.5 mm²).
During the wiring, it is necessary to respect the EMC specifications (see also 'Thermocouples').
The operating current is between 0.3 and 1 mA. Higher currents may generate notable self-heating effect thus lead to measuring errors.

During electric connection of the resistance probe, operators must make sure do not exceed the limited current indicated by the manufacturer (even when the installation is disturbed).

2.4 Temperature sensors with integrated converters

In order to facilitate small electric signals' transmission via long lines of distribution (i.e. in the power plants) and to reduce the high costs due to expensive wirings, it is possible to integrate converters near the area of sensors, in this case, the sensor's standard signal (i.e. 4.20 mA) can be sent to the measuring device by a simple two-wire cable.
Circuits of multiple conductors can be used to do this.
Before using a measuring converter, relevant operating instructions must be consulted, provisions concerning the operations of an electric installation must be observed, regulations and directives in terms of protection against explosions must be respected.
In case of a process measurement at high temperature, the transmitter shall be moved using an extension cable between the head and the thermowell. In general, the maximum temperature at the transmitters is +85°C, which shall be observed according to specific operating notice.

2.5 Use of temperature sensors

The above mentioned sensors are the type of direct contact, which means the sensors shall be put in direct thermal contact with the measuring location, in order to evaluate the temperature through thermal control via convection or thermal transfer. The contact thermometer can indicate its own sensor's temperature. By choosing a suitable measuring point (position of sensors, penetration depth, thermal insulation against the heat dissipation, etc.), the operator shall make sure that the temperature difference between the measuring location and the sensor is minimized. Further, the thermometer shall be carefully chosen according to its reactivity in measurement of variable temperatures (temperatures changes).

3. Use in explosive zones

According to Atex directive 94/9/CE, restorations (repairs) can only be done in the following conditions:

- If the electric component on which depends the anti-explosion protection has been restored, it can be put back into operation only after the release of the expert's report, certifying that the new component once again meets the essential requirements in terms of protection against the explosions.
- The above rule is no longer applicable when the component has been submitted to its manufacturer for a target testing, and the manufacturer certifies it meets the essential requirements in terms of protection against the explosions,.
- The repairs can be carried out only with original spare parts, provided by the original manufacturer; otherwise, the requirements in the conformity certification may not be met. All purchase orders of spare parts shall include the precise indications of the last delivery, i.e. for the EExd, EExi type sensors, the conformity certification number, the purchase order number, the manufacture number as well as the item number shall be attached.
- Thermometers, as elements of service which are protected against explosions, are considered compliant with the technical safety requirements only when the whole chain of fabrication respects the safety requirements. The measuring elements or connecting heads must not be the only parts who meet the requirements in terms of anti-explosion protection.
- If KMP provides some thermometers without protection sheaths, which are intended for use in explosive areas, the operator shall make sure that these thermometers are used only in the authorized areas according to conformity certifications or statements of the manufacturer. (I.e. zone 1 or zone 2).

4. Safety

Our sensors have been designed according customers specifications and are proven to be reliable. Having passed every testing, they are in perfect conditions to be delivered. To achieve their state of operation, the safety instructions, the certificates and relevant documentation for operators and objects must be observed scrupulously.
It is absolutely necessary to comply with all general instructions concerning the use of the sensors. Besides from general rules, each chapter in this manual contains concrete process descriptions or handling notices in terms of safety information. Only strict compliance with all relevant instructions will make it possible to protect staff and environment, and only in this way will the devices be operated smoothly.

4.1 Use in compliance with client needs

The safe use of the device is 100% ensured only when all specifications are met. The device's type shall be adapted to product in the installation place.
Transformations or modifications of the device by clients are not allowed, if it is the case, clients' claims for guarantee will be canceled.

4.2 Technical limitations of use

The device is exclusively intended for use within the technical limitations, which are mentioned in our technical data sheets. Concrete technical limitations are as follows:

- The maximum working temperature must not be exceeded.
- The permissible ambient temperature must not be exceeded.
- The right choice of envelope protection type is important during the operation.

4.3 Guarantees

The manufacturer is not responsible for damages caused by use contrary to original plans, non compliance with the instructions, intervention of unqualified staff, and modifications on operator's own initiative. The guarantee becomes invalid. In case of damages, our responsibility is limited to compensatory benefits, as indicated in the general conditions of sales. All subsequent costs reimbursements and defective sensors' immobilizations are excluded.

4.4 Operator's obligations

Before the use in corrosive or abrasive locations, operators shall make sure of the resistance of all elements which are supposed to have direct contacts with these substances. KMP will help you make the right choice without assuming any responsibilities.
Operators shall be obliged to comply with current national directives in terms of operation control and electrical devices maintenance and repairs.

4.5 Staff qualification

- A qualified team is the one who is able to evaluate the tasks and to identify the potential risks with their professional background (education, knowledge, experience) as well as their familiarity with the relevant standards.
- Installation, operation and maintenance of the devices can only be accomplished by specialized staff, who is trained and authorized by the operator.
- A qualified team must read and understand the instructions given in this manual and comply with them.
- In the explosive environment, the staff must get qualified knowledge and skills to work on the protected devices.

4.6 Transportation safety instructions

If operators should transport the equipment, the following instructions must be complied with:

- Do not expose devices to humidity during the transportation. Some measures must be taken to protect the devices which are subject to humidity.
- The device must be packaged so as to be protected against shocks, i.e. choosing air bubbles or plastic foams as packing material.
- The operator must control if there are some eventual devices damage due to non-compliant transportation.
- Damages due to transportation must be indicated on the shipping documents. All claims for compensation must be submitted to the shipper before installation.

4.7 Safety instructions for electrical installation

- The electrical connection shall be executed only by qualified and authorized staff following the electrical diagrams.
- Instructions concerning the electrical connection must be complied with; otherwise, electrical protection may be jeopardized.
- Safe insulation of electric circuits, which are dangerous in contact, is ensured only when the connected devices meet the VDE 0106 T.101 requirements (fundamental requirements for safe installation)

5 Assembly

5.1 Installation

Thermocouples or resistance probes shall keep perfect contact with the measuring location.
In order to prevent heat dissipation errors, the penetration depth in the measuring location shall adhere to the following basic formula:

- 5-8 times the protection sheath diameter in liquids
- 10-15 times the protection sheath diameter in gases

If only very short insertion depths are possible, it is necessary to opt only for special manufacturing without extra protection sheath. In this case, assembly on a bent pipe might be useful; the protection sleeve must be designed on the opposite direction of the liquid circulation.

5.2 Pipes

Operators shall make sure to maintain a good contact at all junction points. Further, they should take measures against penetration of humidity, dirts, corrosion, and electrical disruptions.
Pipe insulation shall be realized following the environmental influences (dry, humid, chemical, corrosive, and hot). Ambient temperature in the pipe and connecting head shall not exceed +100°C, or +85°C with electronics on the head. Current standards and directives must be complied in each case.
All measuring systems shall be operated, if possible, without being grounded or being only connected to a point on the ground; for thermocouples connected to the protection sheath, the sheath shall be the only point which is connected to the ground.

5.3 Protection sheath

For temperature up to 500 °C, thermocouples can be assembled in any positions; from 500 °C, it is recommended that sensors are assembled in vertical position.
Ceramic sheaths shall be preserved from shocks and twisting.
It is necessary to prevent sudden thermal shocks, for example : direct contact with flame.
As soon as elements are integrated in a hot area, they have to be inserted according the following fundamental formula:

- From 600 to 1100°C with approx. 10-15 cm per minute
- From 1100 to 1600°C with approx. 1-2 cm per minute

This rule is also applicable to extension cables.
Horizontal lengths in cantilevered position should not exceed 600mm for temperature upper 1200°C.

6 Maintenance/ repairs

The entire circuit of temperature measurement as well as temperature sensors shall be tested on a regular basis, as for :

- Wear and tear of protection sheaths due to mechanical or chemical attacks,
- Change of drift of measuring elements due to aging problems,
- Change of insulation resistance due to humidity and dirtiness,
- Contact with conductive junctions,
- Alteration of thermometers and pipes due to mechanical and chemical influence.
- Insulation resistance of the entire measurement circuit (pipes and thermometers) which is not grounded shall be higher than 1 MΩ (measurement at 100 VDC).

The wiring of resistance probes measurement circuit is controlled with replacing the measuring element by a listed fixed resistor so that a certain temperature can be simulated.
The measurement circuits of thermocouples are controlled by connecting with a listed sized voltage which takes the place of the thermocouple (mV).
In these two cases, larger deviations from set values can be defined, and if the thermometer or the instrumentation could be the cause of the operating trouble.

7 Error messages

7.1 Verification / rapid test

If temperature sensors are dismantled at an ambient temperature, a rapid test can be carried out.
The following equipments are required to run the test:

- Multimeter with appropriate DCV measuring range (f.ex. 200mV)
- Resistance measurement device or resistance measurement bridge (measuring range up to about 400 ohms)
- Insulation voltage testing device 50 – 100 DCV, measuring range from 100 Mohms

Standard verification tests:

- Insulation and continuity test
- Internal wires break verification test by small rapping (rattling noises and jumping display)

A thermocouple is in accordance when the conduction resistance at ambient temperature is lower than 20 Ω (for thermoelectric wires, diameter larger than 0.5 mm) and insulation resistance is higher than 100 MΩ (insulation resistance measurement is feasible only on isolated measuring points).

A resistance probe is in accordance when resistor value at ambient temperature is about 110 Ω (at Pt100) and insulation resistance is higher than 100 MΩ.

The heating of thermocouples or resistance probes between 200°C and 400°C (without temperature control) enable to make additional deductions from interruptions, polarities (for thermocouples), an insulation resistance too low, etc.

Comments

According to EN 60584 (standards for thermocouples) and EN 60751 (standards for resistance probes), the thermometers' tolerance can only be precisely complied with through the determination of every signal produced by a specific temperature measurement (comparative measurement by comparison with a known normal data, or fixed points temperature measurement).
Generally, the measuring process can only be conducted in a fully equipped calibration laboratory and with non-assembled devices.

7.2 Troubleshooting

The entire measurement circuits must be tested on a regular basis. The following table presents the main troubles, the causes of the troubles as well as relevant remedies.

7.2.1 General types of trouble

Trouble	Cause	Remedy
Measuring signals trouble	Electrical / magnetic disruptions	Keep at least a distance of 0.5 m when installing measuring cables in parallel
		Electrostatic protecting screen through a film/string grounded to a point
		Twisting of the conductors (pairs) against the magnetic disruptions
		Crossing of the cables at right angles with disruptive power conductors.
		Use of measuring transducers.
	Ground loops	Only one point of the circuit to be grounded or use of a « floating » measuring system (without being grounded)
	Diminution of insulation resistance	There are possibilities that humidity has penetrated the thermometer, in this case, operators can evaporate the humidity or construct a new sealing (if possible).
		Replace measuring elements
		Verify if the thermometer is thermally overloaded
Delayed response, Display trouble	Inappropriate location : - in the flow zone - at a heat source	The thermometer must be able to circumscribe the measuring environment freely; verify location
	Incorrect installation : - peneration depth too low - too much heat dissipation	Test the penetration depth Guarantee thermal contact, especially in superficial measurement, through appropriate surface contact and/or by means of heat transfer.
	Interior walls of the protection sheath too thick, drilling hole of the protection sleeve too large	Adjust the dimension of the protection sheath Use thermal conduction fluid
	Dirty protection sheath, deposits in the exterior of the sleeve	Remove deposits during maintenance. Arrange a new sheath material or another measuring point
Interruption of thermometer	Vibration	Assembly measuring element on spring
		Choose a lower assembly length
		Change measuring point
		Use a vibration resistant design
Protection sheath heavily corroded	Composition of the measuring location is not adapted or has been altered	Test measuring environment
		Use a surface coating
	Bad choice of materials of the sheath	Test sheath material, and change sleeves if necessary
		Define protection sheath as wear part to be changed regularly

7.2.2 Trouble related to thermocouples

Trouble	Cause	Remedy
Display of thermal oscillation on the thermocouple with otherwise a perfect circuit structure	Point of comparison – instable temperature/tension of comparison	The temperature or tension of comparison shall be maintained constant, below 0.1%. (Instruments to be verified). Full power in measurement for non-mettalic thermocouples; around medium power for noble metal thermocouples
Significant deviation on the temperature display from thermocouples' set values	Thermocouple of poor quality	Test thermocouples and pipes as for : Good matching. Compensating cables of good quality. Correct polarity Permissible ambient temperature at connecting head.
	Poor electric contacts (oxidation)	
	Thermoelectric stray voltage, galvanic elements	
	Compensating cable of poor quality or wrong polarity	

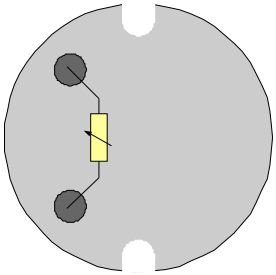
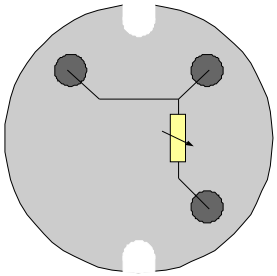
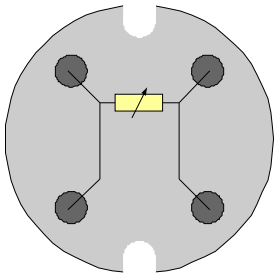
7.2.3 Trouble related to resistance probes

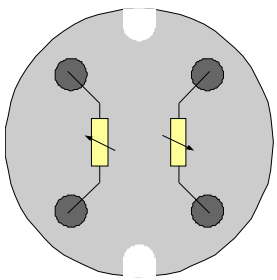
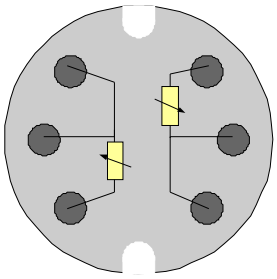
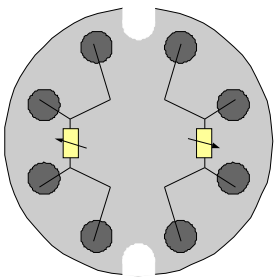
Trouble	Cause	Remedy
Temperature display too high or oscillating, despite of clear section and precise measuring resistance of the resistance probe.	Electric resistance too high and not well balanced	If it is still possible : Use of cables of bigger section, possibly from a better access. Shorten pipes length. Use of compensating cables. Convert to 3-wire or 4-wire circuit. Use of measuring transducers with probe's head.
	Change of resistance at the pipe level, conditioned by temperature (for 2-wire circuit)	
Display of thermal oscillation on the resistance probe with otherwise a perfect circuit structure	Inconstant current source for proportional current.	Current source shall be constantly maintained below 0.1%. Full power in measurement with a modified bridge and measuring current (4-wire circuit).

8. Electric connection

8.1 Connection for resistance probes

Connection type diagram

DIN rail mounting standard EN 60751		
simple		
2-wire mounting circuit	3-wire mounting circuit	4-wire mounting circuit
		

DIN rail mounting standard EN 60751		
double		
2*2 wire mounting circuit	2*3 wire mounting circuit	2*4 wire mounting circuit
		

Connection type diagram

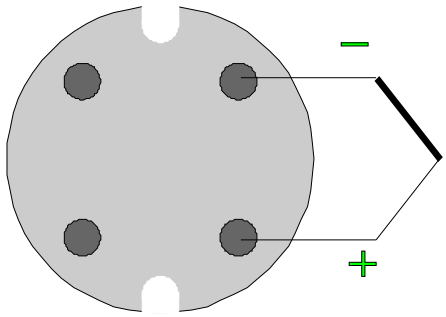
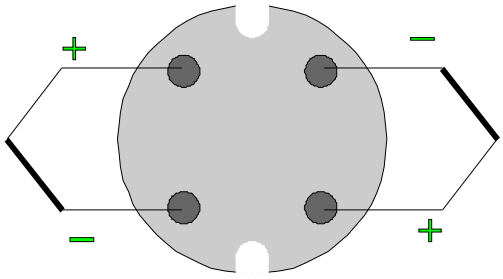
2-wire mounting: it's the simplest mounting type. Wire resistance is in line with the resistance to be measured. Systematic error corresponds to the sum of resistance.

3-wire mounting: this type of mounting demands three equal resistance and can minimize systematic errors due to line resistance. There exists some contact resistance problems and some balancing problems of thermal drains.

4-wire mounting: in this type of mounting, with two measurement being realized, line resistance is eliminated, and thermal drains balancing problem is resolved. However, there still exists some contact resistance problems.

8.2 Connections for thermocouples

Connection type diagram

DIN rail mounting standard EN 60584	
simple	**double**
	

Connection type diagram